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THE EMERGENCE OF UNTRAINED MANDS AND TACTS IN CHILDREN WITH AUTISM

HEATHER E. FINN

NEW ENGLAND CENTER FOR CHILDREN AND NORTHEASTERN UNIVERSITY

CAIO F. MIGUEL

CALIFORNIA STATE UNIVERSITY, SACRAMENTO

AND

WILLIAM H. AHEARN

NEW ENGLAND CENTER FOR CHILDREN

Despite Skinner's (1957) assertion that verbal operants are initially functionally independent, recent studies have suggested that in some cases the acquisition of one verbal operant (e.g., mand) gives rise to the other (e.g., tact) without explicit training. The present study aimed to evaluate the functional independence of mands and tacts during instruction with children with autism. Four boys with autism (3 to 6 years old) were taught to construct two 4-piece structures. Two participants were taught directly to mand, whereas the other 2 were taught to tact the names of the pieces. The effects of training were evaluated in a multiple probe design across verbal operants and tasks. Three of the 4 participants demonstrated an immediate transfer of control from 1 verbal operant to the other. These results were consistent with previous research with typically developing young children.

Key words: autism, functional independence, mands, tacts, verbal behavior

In *Verbal Behavior,* Skinner (1957) described verbal operants as units of behavior that are composed of responses of identifiable form that are functionally related to one or more independent variables. He outlined several distinct verbal operants, including mands, tacts, intraverbals, and echoics. Skinner suggested that because verbal operants are under control of distinct variables, they should be functionally independent, in that the development of one may not lead necessarily to the emergence of the other. This functional independence is relevant to our instructional procedures, in that we should teach the verbal functions separately rather than assume that all verbal functions will exist when only one has been programmed explicitly (Sundberg & Partington, 1998). However, if the training of one verbal operant leads to the emergence of another untrained operant, then a more efficient approach to verbal behavior training can be devised.

Research on functional independence of verbal operants has focused primarily on mands and tacts, although other relations also have been evaluated (e.g., Miguel, Petursdottir, & Carr, 2005). Despite early support for the functional independence of mands and tacts (Hall & Sundberg, 1987; Lamarre & Holland, 1985; Partington, Sundberg, Newhouse, & Spengler, 1994; Simic & Bucher, 1980; Twyman, 1996), more recent research has described conditions that would lead to the transfer from one operant to the other (Arntzen & Almas, 2002; Carroll & Hesse, 1987; Petursdottir,

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Address correspondence to Caio Miguel, Department of Psychology, California State University, Sacramento, 6000 J Street, Sacramento, California 95819 (e-mail: miguelc@csus.edu).

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Carr, & Michael, 2005; Sigafoos, Doss, & Reichle, 1989; Sigafoos, Reichle, Doss, Hall, & Pettit, 1990; Sundberg, San Juan, Dawdy, & Arguelles, 1990; Wallace, Iwata, & Hanley, 2006).

In one of the most cited studies suggesting functional independence, Lamarre and Holland (1985) taught three 5-year-old typically developing children to mand and tact the abstract directions of ''on the left'' and ''on the right.'' The experimenters taught some of their participants to tact the placement of an object and tested for the emergence of mands, and they taught others to mand the locations and tested for the emergence of tacts. When the untrained operant did not emerge, it then was trained directly. Lamarre and Holland then used reversal training in which the meaning of the phrases was reversed (i.e., ''on the left'' was used to refer to the socially accepted right side). The authors reported that, for six of the nine participants, reversing one operant did not result in the reversal of the other without direct training. For the other three participants, a transfer of control did emerge during reversal training, but it was unclear whether the results for these three participants indicated a transfer between verbal operants or if their results were due to prior exposure to the training condition.

Hall and Sundberg (1987) also demonstrated functional independence between mands and tacts with two deaf individuals with intellectual disabilities. The two participants learned to complete four behavior chains (e.g., making soup, getting candy from a vending machine) that resulted in direct reinforcement (i.e., soup, candy). The participants then were taught to tact all of the pieces required to complete the chains. Throughout training, probes were conducted to determine whether mands emerged when the materials that were unavailable were needed for a step in the chain. Their results suggested that mand responses occurred only after the mand function was trained directly.

Some studies also have described conditions that led to functional interdependence or transfer between the verbal operants (Arntzen & Almas, 2002; Carroll & Hesse, 1987; Petursdottir et al., 2005; Sigafoos et al., 1989, 1990; Sundberg et al., 1990; Wallace et al., 2006). Wallace et al. (2006), for instance, taught three participants with developmental disabilities to tact high-preference (HP) and low-preference (LP) items and then tested to see if the responses occurred as mands. During initial testing, both the HP and LP items were emitted equally as mands, but after tact training, the HP items were manded more frequently and the LP items were manded at near-zero rates. Wallace et al. concluded that transfer of control from one verbal operant to another was more likely to occur when the item was highly preferred. The authors also suggested that the failure to produce novel mands in the earlier studies may have been a function of not using highly preferred items during training. In other words, the lack of transfer may have been due to the absence or weakness of the establishing operations to mand for the items. It is also possible that the establishing operation for highly preferred items was present during tact training. If so, then the establishing operation may have inadvertently acquired control over the form of the response during tact training, which may have facilitated the transfer.

Petursdottir et al. (2005) also evaluated the functional independence of tacts and mands. They trained four typically developing preschool children to either mand or tact items in two assembly tasks. During pretraining, participants were taught to complete one cube and one puzzle. After pretraining, participants learned to either tact or mand the pieces using arbitrary, unfamiliar terms and then were tested on the other operant. During discrete-trial tact training, participants were taught to tact each of the four pieces of an assembly task; each correct response produced praise and a sticker. During mand

training, the experimenter provided three of the four pieces needed to complete the task (i.e., contrived establishing operation) and kept the missing item out of the participant's sight. When participants attempted to complete the task, the experimenter prompted, "What do you need?," delivered echoic prompts as needed, and provided the item for correct responses along with praise and a sticker at the completion of the entire assembly. All four participants demonstrated the emergence of tacts after mand training, but only two of the four demonstrated mands after tact training. Petursdottir et al. hypothesized that self-echoic responding that was observed to occur during mand training may have facilitated mand-to-tact but not tact-to-mand transfer. One limitation of their study was the physical similarity between the outline of the missing puzzle piece and the piece itself. Thus, the outline may have acquired discriminative control over the mand response, which may have accounted for the observed transfer.

More recently, Egan and Barnes-Holmes (2009) taught four boys with autism to mand for preferred items using adjectives (e.g., small bowl) and tested for both mands and listener responses (i.e., receptive discrimination). After training, three of the four participants were able to tact objects using adjective sets, but only when asked "What is it?" This suggested that tacts were partially under intraverbal control. All participants demonstrated some listener responding after mand training, but only one responded at high levels. Although these results replicated the findings of Petursdottir et al. (2005) with respect to the emergence of tacts, the emergence of mands after tact training was never evaluated.

The current study extends the work by Petursdottir et al. (2005) and Egan and Barnes-Homes (2009) by assessing the transfer between mands and tacts during instruction with children with autism. As in Petursdottir et al., participants were taught to either mand or tact parts of a construction task and were tested for the emergence of the untrained verbal operant. In addition, the physical properties of the chosen tasks eliminated the possibility of discriminative control by the missing piece during mand training and testing.

METHOD

Participants

Four boys with a diagnosis of an autism spectrum disorder participated in the study: Juan, Stephen, Jeff, and Liam. All participants were between the ages of 3 and 6 years old. They attended an early intervention program for children with autism for approximately 30 hr per week. Teacher reports indicated that three of the four participants frequently demonstrated both mand and tact responses. Liam's mand repertoire was less established (see additional information below). Permission of the parents and clinical supervisors was obtained prior to each child's entry into the study.

Juan was 5 years 6 months old at the beginning of the study. He communicated using six- to eight-word sentences. When assessed on the Peabody Picture Vocabulary Test-3 Form A (PPVT-3; Dunn & Dunn, 1997), which is used to assess receptive vocabulary, he achieved a raw score of 39, a standard score of 76 ($M = 100 \pm 15$), and an age equivalent of 3 years 1 month. These results indicate that Juan's understanding of single spoken words, as measured by this test, was in the low average range. On the Expressive One Word Picture Vocabulary Test (EOWPVT; Brownell, 2000), which is used to assess single-word expressive vocabulary, he scored a standard score of 80 and an age equivalent of 3 years 4 months.

Stephen was 3 years 10 months old at the beginning of the study. He communicated using six- to eight-word sentences. On the PPVT-3 Form A, he achieved a raw score of 38 (a standard score could not be determined due to his performance on the test) and an age equivalent of 3 years 1 month. On the EOWPVT, he scored a standard score of 105 and an age equivalent of 3 years 3 months.

Jeff was 5 years 0 months old at the beginning of the study. He communicated using three- to five-word sentences. On the PPVT-3 Form A, he achieved a raw score of 38, a standard score of 79, and an age equivalent of 3 years. On the EOWPVT, his standard score was 71 with an age equivalent of 2 years 8 months.

Liam was 6 years 8 months old at the beginning of the study. He communicated using one- to three-word utterances. According to teacher reports, his mand responses occurred less frequently than his tact responses and usually occurred in the context of a teacher presenting an array of items for a choice. He demonstrated mand responses for items that were out of sight, but this occurred infrequently and only in the context of a few items (e.g., a toy house located in a different classroom). On the PPVT-3 Form A, he achieved a raw score of 14, a standard score of 40, and an age equivalent of less than 1 year 9 months. On the EOWPVT, he scored a 56 and age equivalent of 2 years 7 months.

Setting and Materials

All sessions were conducted in a small, windowless room (3 m by 4.5 m) or in the participant's typical schoolwork area (a cubicle with three walls; 1.25 m by 1.25 m). Both spaces contained a table, chairs, and the necessary construction materials. The experimenter and the participant sat next to each other at a child-sized table. Sessions lasted 10 to 30 min, and each participant attended three to five sessions per week. Most sessions were videotaped for interobserver agreement scoring purposes unless another experimenter was present to score the data as the session occurred.

Two four-part construction tasks were used. The first construction task was composed of a series of Wedgits pieces that had been glued together to make up four pieces of varying colors and unique shapes. All of the pieces had different combinations of colors, and none were all one color. When all four pieces were put together, they formed a unique shape that could not be completed correctly without all four pieces (see Figure 1, top). Unlike in Petursdottir et al. (2005), when one piece was missing, there was no outline of its shape evident in construction of the pieces that were present. Similarly, the second construction task was composed of a series of magnet pieces that had been glued together to make up four pieces with multiple colors and unique shapes that could not be completed correctly without all four pieces (see Figure 1, bottom). The participant needed to stack the magnet pieces on top of each other in a particular order. When a piece was missing, the task could not be assembled, and no outline of the shape of the missing piece existed.

Four three-letter one-syllable names were chosen for the pieces of the construction tasks in consultation with speech and language pathologists to ensure that similar phonetic effort was required to produce them. As in Petursdottir et al. (2005), nonsense words were used to minimize exposure to the names prior to or outside the experimental sessions. The names of the pieces were held constant across participants. They were *cad*, *sug*, *tiv,* and *nam* for Construction Task (CT) 1 and *dazz*, *wik*, *pess,* and *kig* for CT 2.

Dependent Variables and Data Collection

The dependent variables were the number of correct verbal responses that occurred independently during the mand and tact testing conditions. A tact was recorded when the question ''What is this?'' or ''What's its name?'' evoked the nonsense word that corresponded to the construction task piece presented by the experimenter (e.g., ''sug''). A mand was recorded when one of the pieces needed to complete a construction task was out of sight, and the question, ''What do you need?,'' evoked the corresponding nonsense word. The number of correct autoclitic frames (i.e., ''It's a,'' ''I need'') preceding the arbitrary topographies was recorded in addition to the verbal operants (mand or tact).

Figure 1. Construction Task 1 (the Wedgits set) is pictured in the top panel, and Construction Task 2 (the magnet pieces) is pictured in the bottom panel.

On each testing or training trial, the experimenter recorded a correct, an incorrect, or a prompted (training only) response on a data sheet. A response was scored as correct if it contained the target response form and did not contain any of the other response forms. A response was scored as incorrect if the target response form was not emitted within 20 s of the experimenter's initiation of a testing trial, within 5 s of the initiation of a training trial, or if another response form was emitted before or within 5 s of the target response form. During training, prompted responses were considered correct if emitted after the prescribed prompt. The experimenter also recorded the presence or absence of the corresponding autoclitic frame.

Interobserver Agreement

A second observer independently recorded data for 46% of all sessions. On each trial, an

agreement was scored if both the experimenter and the second observer independently recorded a response identically as either prompted, correct, or incorrect based on the definition above. Interobserver agreement was calculated by dividing the number of agreements by the total number of trials and converting this number to a percentage. Agreement for individual sessions ranged from 88% to 100% across all participants and averaged 99% for Juan, 99.6% for Stephen, 99% for Jeff, and 99% for Liam.

Treatment Integrity

A second observer scored the experimenter's behavior for 20% of all training sessions. Trials were scored as correct if (a) the correct instruction was delivered (i.e., "What is it?" or "What do you need?" for tact and mand trials, respectively) and (b) consequences associated with the targeted operant were delivered (i.e., praise and token for tacts; the requested item for mands). Incorrect trials were scored if (a) incorrect instructions were delivered, or (b) if during training of one operant, the experimenter delivered the consequences for the other verbal operant, or if no consequences were delivered. Treatment integrity was calculated by dividing the number of correct trials by the total number of trials and converting the outcome to a percentage. Scored trials were implemented correctly during training of both the mand and the tact in 99.6% of opportunities across all participants.

Design

The effect of training one verbal operant on the emission of the other, untrained verbal operant was evaluated in a multiple probe design across tasks. Verbal operant training and construction tasks were counterbalanced across participants (Two participants were trained to mand first and two participants were trained to tact first.) Of the two participants who were trained to mand first, one was taught to mand the pieces of CT 1 and the other was taught to mand the pieces of CT 2. Of the two participants who were trained to tact first, one was taught to tact the pieces of CT 1 and the other was taught to tact the pieces of CT 2.

Procedure

Prerequisite skills assessment. All participants were observed to make sure they could emit mands and tacts for commonly available items in their natural environment. To assess participants' tact repertoire, they were shown items from the environment and asked, "What's this?" For mand probes, participants were asked, "What do you want to do?," with notation of whether the selected items were visible or not, or they were given a task to complete with a familiar component missing (e.g., cutting out shapes with scissors missing, coloring with crayons missing). During their play breaks at school, each participant tacted familiar items in their environment and manded for items that were not in view. Jeff and Liam never used autoclitic frames prior to the study. Juan and Stephen consistently used the mand autoclitic frame but not the tact autoclitic frame. To ensure that the two operants had equally strong or weak autoclitic frames, Juan and Stephen were exposed to a booster autoclitic session in which the autoclitic frames "That's a —" for tacts and "I need a —" for mands were trained directly using modeling and praise. Familiar items were presented with the question, "What's this?," for tacts, and tasks were presented with items missing for mands. Jeff and Liam were not exposed to this training because they had equally limited frames for both operants.

Preference assessment and token-based reinforcement. Participants earned a token for each correct response during pretraining, mand training, and tact training. Ten tokens could be exchanged for a preferred item. During the testing sessions, tokens were provided contingent on correct responding on interspersed maintenance trials (i.e., presented after each test trial; see below). A multiple-stimulus without

replacement (MSWO) preference assessment (DeLeon & Iwata, 1996) was conducted for each participant prior to the beginning of the study. Items included in the arrays were selected based on teachers' reports. Results of the MSWO indicated that the following items were ranked as highly preferred: cookies and candy corn for Juan; chocolate chips and crackers for Stephen; a computer reading program and an Elmo toy for Jeff; and Doritos for Liam. Before each session, the participant was given a choice from the most highly preferred items and could access that item with tokens earned throughout the session.

Pretraining. All participants were exposed to a pretraining phase in which they were taught via backward chaining to complete the two construction tasks that were used in the study. The order in which they were trained was counterbalanced across participants. The pieces of the construction task were presented and the experimenter stated, "Put it together." Prompts were faded from immediate full manual guidance to immediate light physical guidance to 2-s delayed light physical guidance and finally, to no prompt. Prompts were faded after two consecutive sets of four of four correct responses at each prompt level. Tokens and praise were delivered contingent on correct responses at the prescribed prompt level.

Tact training. Participants were trained to tact each of the four pieces that made up the construction task using most-to-least vocal prompting, progressing from a full verbal model to a partial verbal model to a delayed partial verbal model to no prompt. For each trial, the experimenter held up a piece and asked, "What is this?" During training, if participants responded correctly by emitting the correct frame ("That's a —") and verbal topography, the experimenter delivered praise and a token. If participants responded incorrectly (by either not emitting the frame, emitting the incorrect frame, not emitting the verbal topography, or emitting the incorrect verbal topography), the experimenter modeled the correct response and then conducted a correction procedure. The correction procedure consisted of the experimenter removing the piece and representing the piece with the instruction, "What is this?," with an immediate model of the correct response "That's a [name]." The experimenter then repeated the trial at the targeted prompt level. No token or verbal praise was delivered, and the experimenter moved on to the next trial.

One piece of the construction task was trained to mastery before another piece was introduced. Trials were conducted first with Piece 1 until the participant reached the mastery criterion (i.e., 9 of 10 correct). Then, Piece 2 was introduced and trained until the participant reached the same mastery criterion. Next, sessions included alternating presentations of Pieces 1 and 2 until the same criterion was met. Next, Piece 3 was trained to criterion in isolation followed by alternation of the three pieces in nine-trial blocks until eight of nine responses were correct. Piece 4 was then trained to mastery in isolation and then alternated with Pieces 1, 2, and 3 in eight-trial blocks until the participant emitted seven of eight correct responses for three consecutive eight-trial blocks conducted on at least 2 separate days.

Mand training. Mands were trained systematically in a discrete-trial format using most-to-least vocal prompting, progressing from a full verbal model to a partial verbal model to a delayed partial verbal model to no prompt. For each trial, the experimenter presented one of the construction tasks with one piece missing and said, "Put this together." The missing piece was out of sight but within the experimenter's reach. When the participant began to complete the task and was unable to finish it, the experimenter asked, "What do you need?" If the participant responded correctly by emitting the correct frame and verbal topography, the item was delivered with no other consequences. When the participant completed the task, the experimenter delivered a token and praise. If the participant did not respond within 5 s, the experimenter modeled the correct response, and then conducted a correction procedure starting the trial over from the beginning. If the participant emitted a mand for a different piece

of the construction task (i.e., incorrect mand), the experimenter removed it from the construction, handed it to the participant, and implemented a correction procedure in which the response was prompted and the trial was repeated. Training steps and mastery criteria used for mand training were the same as those used for tact training (i.e., one piece to mastery, a second piece to mastery, interspersal, etc.).

Testing. Test sessions were conducted before training (i.e., pretests) and after each training phase (i.e., posttests). During each session, the participant was tested on both mand and tact trials for all of the pieces from the two construction tasks in one eight-trial block per construction task, with each piece presented twice (i.e., one tact and one mand per piece). Test trials were identical to training trials except that no programmed consequences were delivered for responding. That is, the experimenter did not deliver the piece contingent on correct responding during the mand test trials or provide any additional reinforcement (i.e., token, praise) during any of the test trials. Test trials were interspersed with the following four types of maintenance trials: (a) tact trials on which familiar items were presented along with the question "What is this?"; (b) successful task-completion trials, in which the participant was presented with all four pieces of the assembly task, along with an instruction to complete the task; (c) previously trained mands and tacts of the pieces of the construction tasks after they already had been tested within the block; and (d) mastered one-step instructions, gross motor imitations, and social questions. Tokens were delivered for correct responding on maintenance trials. Participants rarely made incorrect responses on maintenance trials; when they did so, the experimenter implemented a correction procedure by using the most intrusive form of prompting (i.e., physical or imitative).

RESULTS

Pretraining

Juan required a total of 20 trials to master completion of CT 1 and 19 trials to master completion of CT 2, in that order. Stephen required 37 trials to master completion of CT 1 and eight trials to master CT 2. Jeff required 10 trials to master CT 2 and nine trials to master CT 1, in that order. Liam required 39 trials to master CT 2 and 17 trials to master CT 1. These results suggest that, for all participants, the second construction task taught was mastered in approximately equal or fewer trials, regardless of whether the task was CT 1 or CT 2.

Transfer Tests

Figure 2 depicts the number of correct mands, tacts, mand frames, and tact frames across construction tasks for Juan. Training data are not graphed but are presented in the text below. During pretests for both construction tasks, Juan never used the correct response topographies to mand or tact the construction pieces correctly. However, he did use the mand frame "I want," followed by an incorrect topography (i.e., the color of the piece rather than the name) a total of seven times across both tasks. During mand training of CT 1 (marked on the top panel), Juan required 90 trials to learn the topographies *cad, sug, tiv,* and *nam*. During the subsequent posttest for CT 1, he continued to emit the trained mands but failed to tact the items during the first probe session. Instead, he continued to label the colors of different pieces (i.e., "red and blue"). In the second, third, and fourth posttests, the experimenter asked "What is its name?" in addition to and following the inquiry "What is this?" during tact test trials. After this, Juan was able to tact correctly all pieces for three consecutive sessions for CT 1. All but one correct mand for CT 1 pieces were preceded by the autoclitic frame "I want."

Juan required 128 trials to learn the topographies *dazz, wik, pess,* and *kig* during tact training of CT 2 (noted on the bottom panel). During the posttests for CT 2, he manded for the missing pieces in four of the four opportunities for three consecutive sessions. He also maintained the

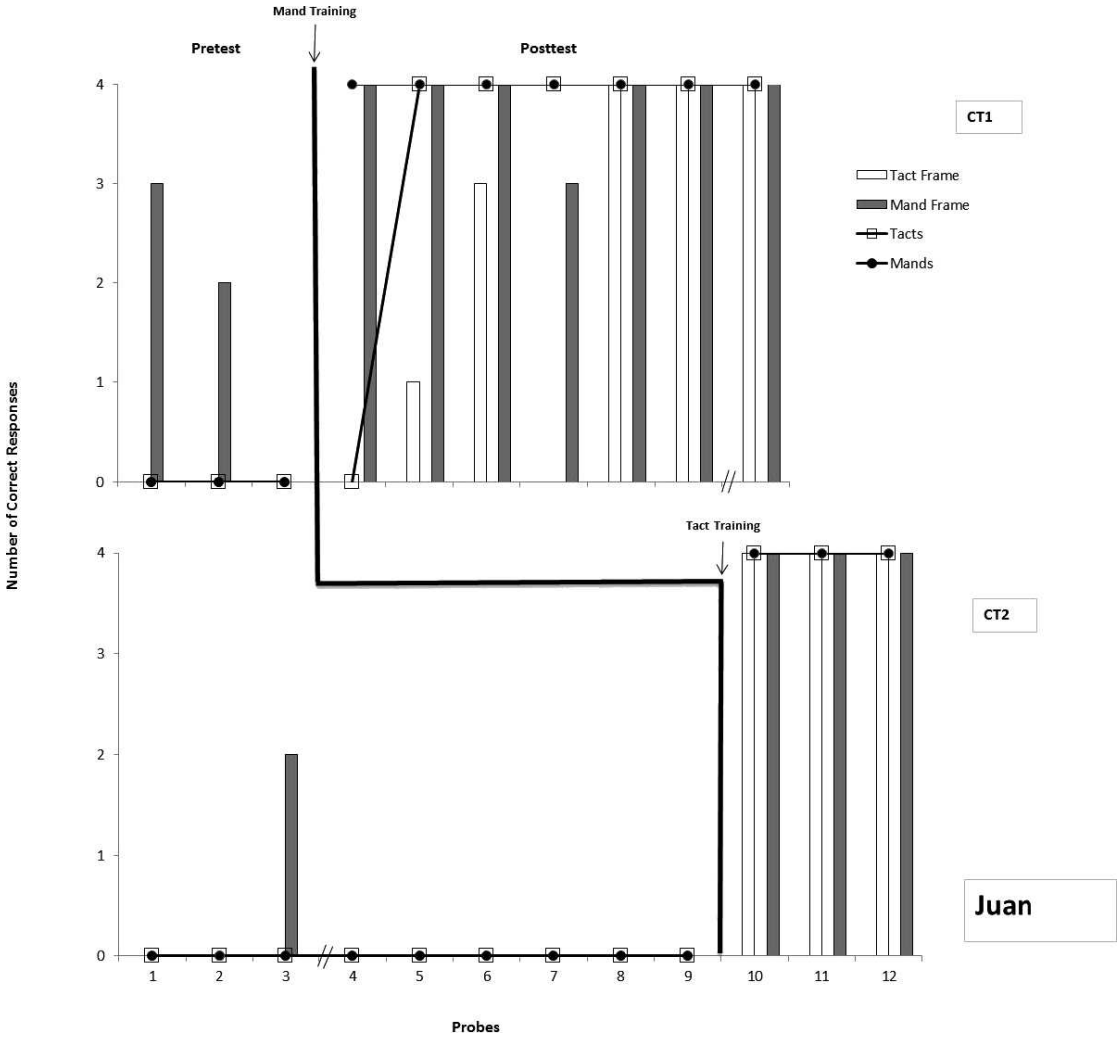

Figure 2. Number of correct mands (filled circles), tacts (open squares), mand frames (gray bars), and tact frames (white bars) during test probes across construction tasks for Juan.

previously mastered mands of CT 1 and tacts of CT 2 for three consecutive sessions. All responses were preceded by their corresponding autoclitic frames.

Figure 3 depicts the number of correct mands, tacts, mand frames, and tact frames across construction tasks for Stephen. During pretests, Stephen did not mand or tact any of the pieces correctly. He did, however, use the mand and tact frames once during the first prestest probe for CT 1, and he used the tact frame three times during the first pretest probe for CT 2. These frames were not followed by any specific vocal topography; he simply emitted the frames and looked back and forth between the object and the experimenter. During tact training of CT 1 (noted on the top panel), Stephen required 110 trials to learn to emit the topographies *cad*, *sug*, *tiv,* and *nam* independently. During posttests for CT 1 (top panel), he emitted the trained tacts in four of the four opportunities across all sessions. Although he emitted only two correct mands during the first posttact-training block, his performance improved with test exposure. Although tact training produced the emergence

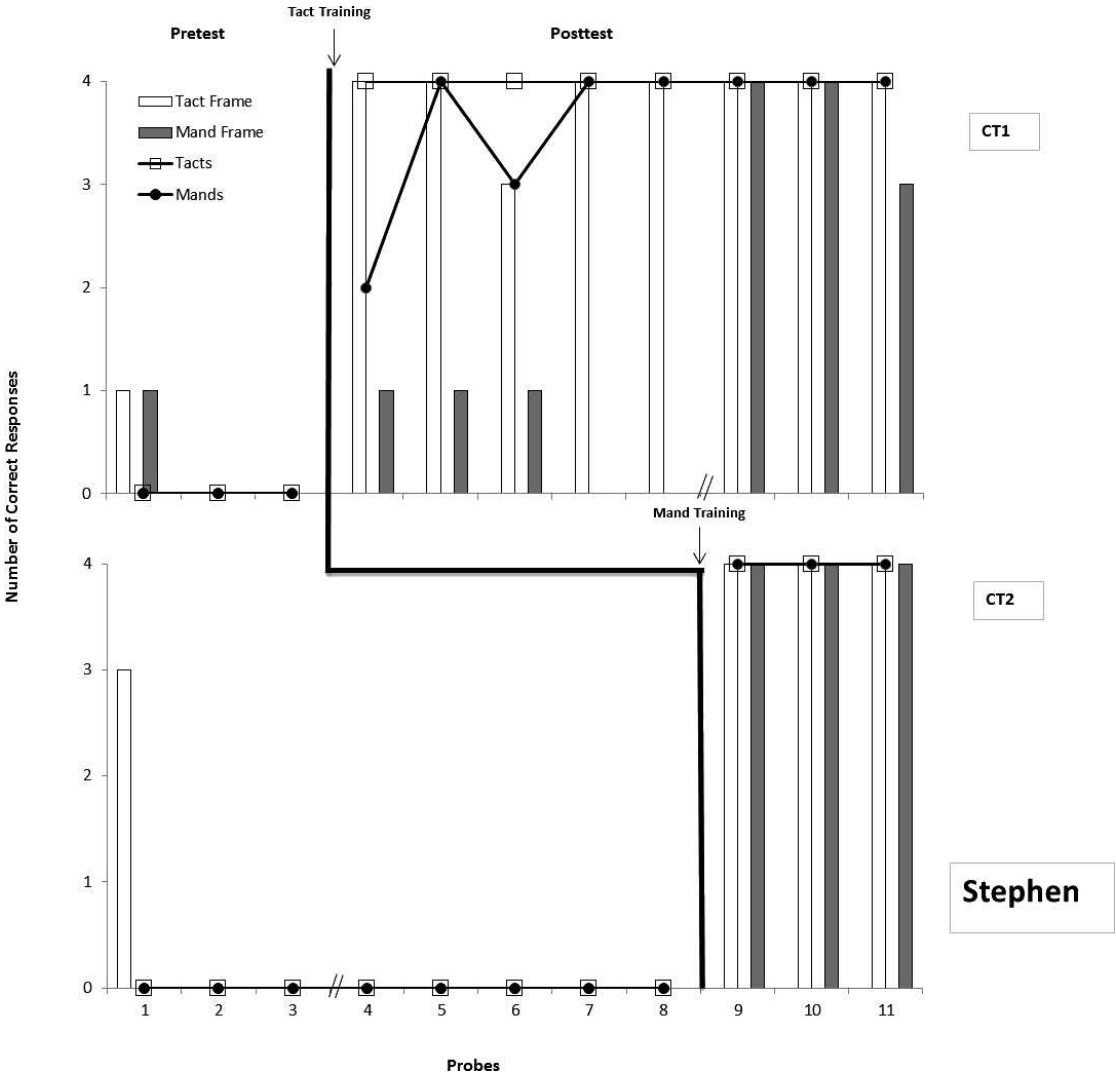

Figure 3. Number of correct mands (filled circles), tacts (open squares), mand frames (gray bars), and tact frames (white bars) during test probes across construction tasks for Stephen.

of correct mands, Stephen emitted the mand frame inconsistently. It was not until mand training of CT 2 that he started to use the autoclitic frame consistently to mand for items in both tasks. During mand training of CT 2 (noted on the bottom panel), Stephen required 50 trials to learn the topographies, *dazz*, *wik*, *pess*, and *kig*. He emitted the untrained tacts in all opportunities across three consecutive sessions. He also continued to emit the trained mands and all corresponding autoclitic frames.

Figure 4 depicts the number of correct mands, tacts, mand frames, and tact frames across construction tasks for Jeff. During pretraining, he never tacted or manded the pieces correctly. He did, however, emit the autoclitic mand frame in almost all testing trials across both construction tasks, and he emitted the autoclitic tact frame three times during the pretests for CT 2 (Probes 1, 2, and 3) and four times during the pretests for CT 1(Probe 2). These frames were followed by incorrect topographies that consisted of made-up words

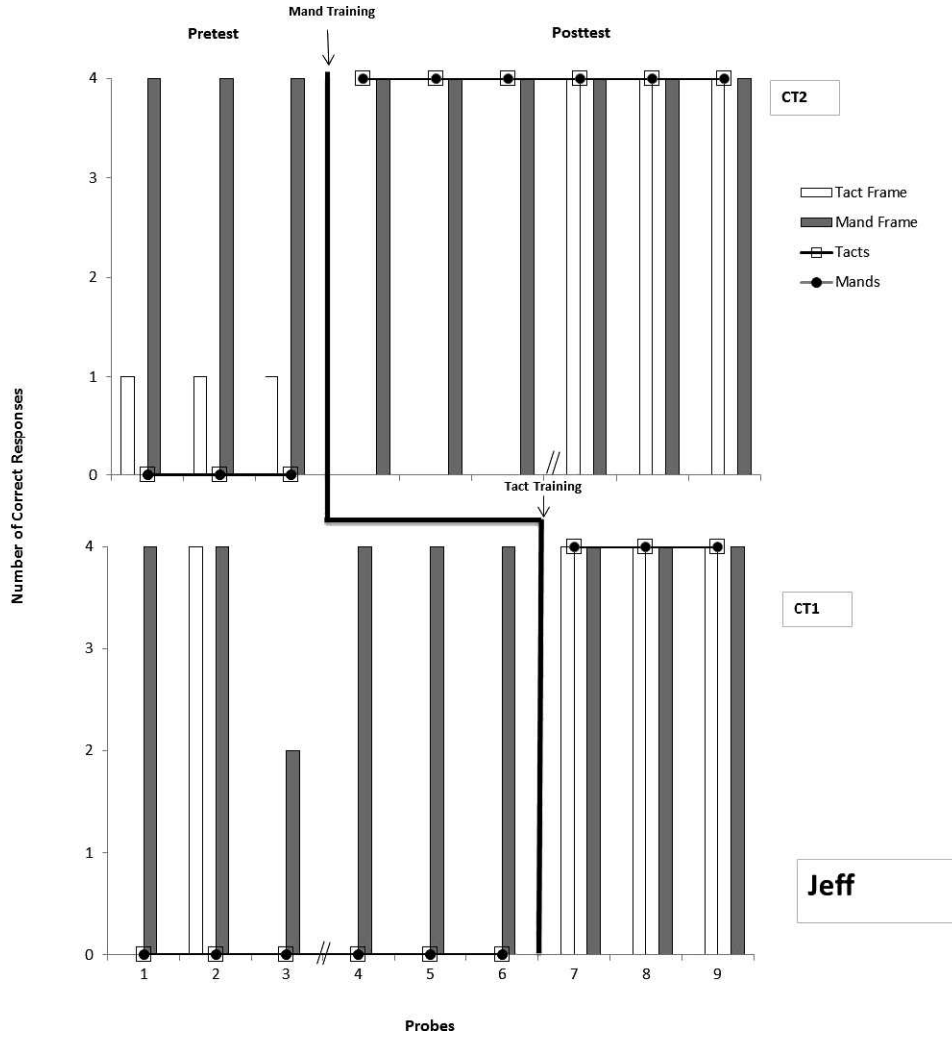

Figure 4. Number of correct mands (filled circles), tacts (open squares), mand frames (gray bars), and tact frames (white bars) during test probes across construction tasks for Jeff.

(e.g., *wuzzah*). During the mand training of CT 2 (top), Jeff required 187 trials to emit the topographies *dazz*, *wik*, *pess*, and *kig* independently. During tact training of CT 1 (bottom), he required 182 trials to master the topographies *cad*, *sug, tiv,* and *nam.* After both mand and tact training, Jeff emitted the untrained operant at 100% accuracy across all sessions. Immediately after mand training on CT 2 (top), he emitted the mand frame at 100% accuracy across all sessions but did not emit the tact frame until tacts were trained directly on CT 1 (bottom). After tact training, all of Jeff's correct mands and tacts were preceded by the corresponding autoclitic frames.

Figure 5 depicts the number of correct mands, tacts, mand frames, and tact frames across construction tasks for Liam. During pretraining, he did not emit any correct mands or tacts. He did, however, emit the tact frame 10 times (Probes 4, 8, and 9), and the mand frame 10 times (Probes 1, 4, 8, and 9) during pretest trials for CT 1. During tact training of CT 2 (top), it took Liam 186 trials to emit the topographies *dazz, wik*, *pess,* and *kig*. After tact training, he did not mand for any of the items

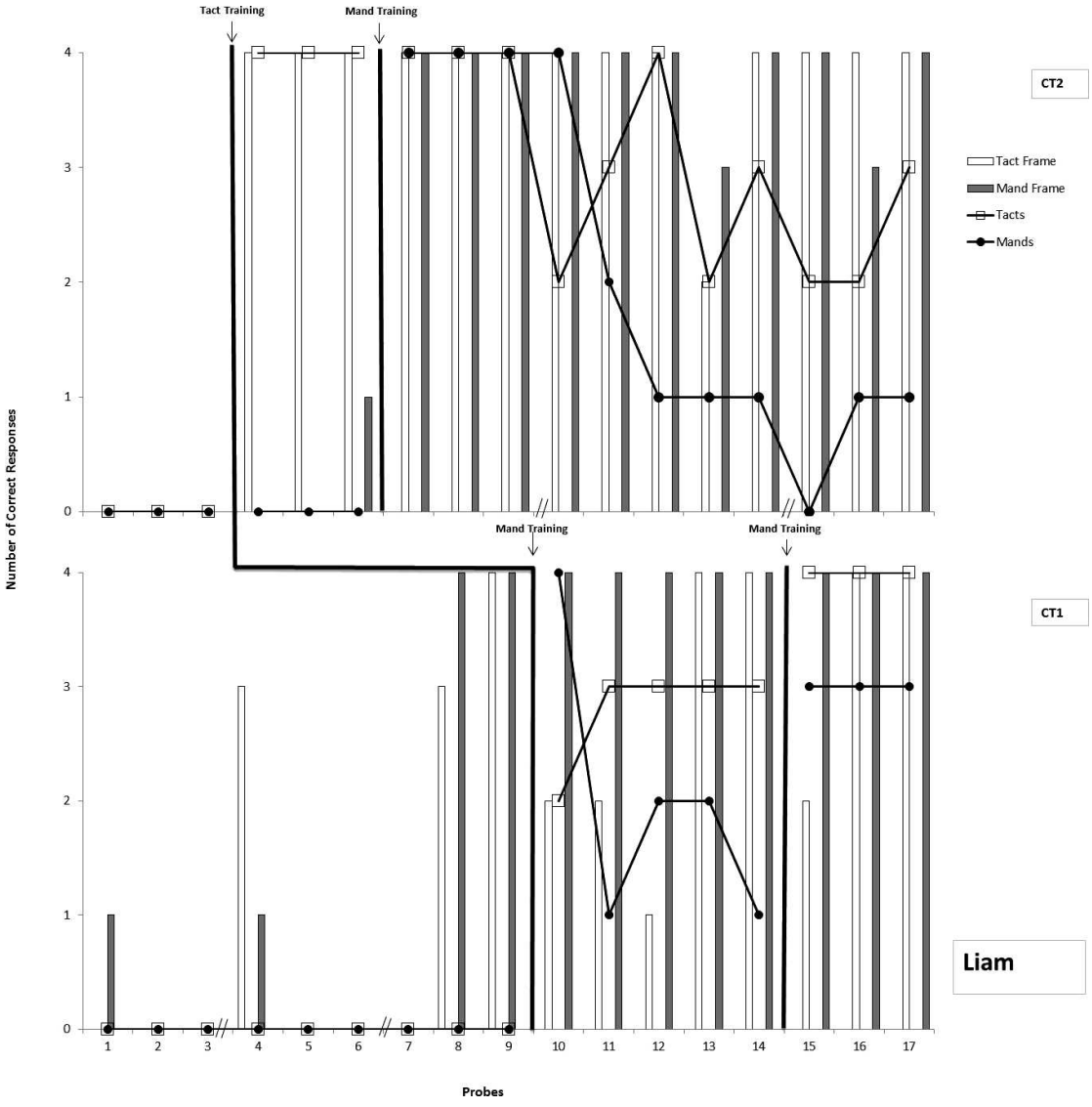

Figure 5. Number of correct mands (filled circles), tacts (open squares), mand frames (gray bars), and tact frames (white bars) during test probes across construction tasks for Liam.

correctly, although he continued to emit accurate tacts preceded by the corresponding autoclitic frame. Liam then was exposed to direct mand training for CT 2. After 50 training trials were required to master the first piece, he reached mastery with all four pieces within the minimum number of trials required. This suggests that, after learning to emit the mand for one piece, he was able to emit the remaining mands without further training. After training was completed, three additional test sessions were conducted. Liam emitted correct tacts and mands using the corresponding autoclitic frames in four of the four of opportunities for three consecutive sessions. However, after initial mand training of CT 1, Liam's performance on CT 2 was not maintained (Trials 10 through 17, top panel).

During mand training of CT 1 (noted on the bottom panel), Liam required 214 trials to learn

to emit the topographies *cad*, *sug, tiv,* and *nam.* During tact posttests for CT 1, he emitted 2 of 4, 3 of 4, 3 of 4, 3 of 4, and 3 of 4 correct tacts, with only some preceded by the frame "that is." His mands, which had been trained directly, also were inconsistent, and his errors were not systematic. Additional mand training sessions were conducted due to the decreasing trend in his trained mand performance. After 24 mand training trials, three additional test sessions were conducted, and correct mands and tacts of CT 1 occurred. He emitted four of the four correct tacts and three of the four mands across three consecutive sessions. The emission of correct verbal operants was not necessarily preceded by correct autoclitic frames. Of note, this second mand training did not seem to affect performance on the previously trained construction task (CT 2).

DISCUSSION

Three of the four participants demonstrated functional interdependence or transfer between mands and tacts. The remaining participant (Liam) demonstrated functional interdependence on only the second construction task, for which tacts emerged after mands were trained. Although tacts did not emerge in the first test probe for Juan, emergence was observed when the discriminative stimulus (S^D) was modified, suggesting that a previously established color-tacting repertoire that had been trained with the original S^D interfered with initial responding. For Juan, Stephen, and Jeff, training in either verbal operant produced emergence of the other, regardless of the order in which the operants were trained. In contrast, Liam did not demonstrate the emergence of mands after tact training. After Liam was taught directly to mand for one piece, mands for the other three pieces emerged. These results suggest that the S^D "What do you need?" may not have been correlated previously with reinforcement for manding and, thus, did not exert appropriate stimulus control over his behavior. When Liam was trained to mand for the pieces of the second construction task (CT 1), tacts for those pieces emerged. This could have been due to stronger controlling variables associated with the mand (motivating operation) facilitating the transfer to the tact, or the participant's history of exposure to the testing conditions and discriminative stimuli. The differing results of Juan, Stephen, and Jeff compared to Liam also could have been related to their verbal skills. Unlike the other three participants, Liam had demonstrated few pure mands before the beginning of the study.

These results are similar to those obtained by both Egan and Barnes-Holmes (2009) and Petursdottir et al. (2005), in that transfer of control between verbal operants was observed. Unlike Petursdottir et al., who observed more transfer from mands to tacts than vice versa, untrained verbal operants emerged consistently for three of the participants. The fourth participant (Liam) emitted the untrained verbal operant after a brief training period for the first construction task and then emitted the untrained verbal operant with the second construction task.

For three of the participants (Juan, Jeff, and Stephen), autoclitic frames did not emerge during tests until each frame was trained directly in one of the construction tasks. In other words, the generalized use of the autoclitic frames started to take place after training had occurred for at least one target. When correct autoclitic frames were emitted during posttests, they always were followed by the correct verbal topography. Moreover, participants never used tact frames to mand or mand frames to tact. For Liam, there was an increase in the use of the autoclitic frame directly after each training session. After exposure to both mand and tact training, he used the frame consistently both to mand CT 1 and CT 2 pieces and to tact CT 2 pieces, but he did not use the frame to tact CT 1 pieces (the untrained verbal operant). This was inconsistent with his prior use of the autoclitic frame across both construction tasks, regardless of which had been trained. Although he emitted tact responses more consistently than

mands throughout the study, he used the autoclitic frame to mand more consistently than to tact. For Liam, use of the autoclitic frame was not correlated with the emission of the correct mand or tact response. The autoclitic frame did not seem to act as a discriminative stimulus that facilitated the emission of the correct verbal operant, which supports the notion that the verbal topographies were not controlled intraverbally by the frame, but were under sole control of the motivating operation (mand) or nonverbal S^Ds (tact).

The use of autoclitic frames during training and testing may have facilitated a transfer of control between verbal operants. Because participants were trained to use the autoclitic frame "That's a —" in response to "What is this?" and "I need a —" in response to "What do you need?," it is possible that, at least for Juan, Jeff, and Stephen, these verbal stimuli may have served as additional intraverbal prompts, thus facilitating the acquisition of the untrained related verbal operant. Because these participants had a history of instruction following, the questions also could have served as conditioned reflexive motivating operations. Thus, these questions may have increased the likelihood of the emission of any of the possible responses, and the presence of the item (tact) or the relevant motivating operation (mand) served as an additional variable that determined the specific form to be emitted. For example, during tact tests, the question "What is this?" (S1) evoked the intraverbal response "This is a —" whose response product (S2) increased the probability of the emission of any of the topographies trained. The presence of the item (S3) served as an additional variable that controlled the emission of the correct response (R1). This form of multiple control has been referred to as *verbal conditional discrimination* or *convergent stimulus control* (Skinner, 1957; Sundberg & Sundberg, 2011).

Another factor that may have facilitated the transfer was the use of tokens for correct responding on maintenance trials that could have been exchanged for highly preferred items at the end of each session. In previous studies, the reinforcement used might have not been potent enough to create sufficiently strong motivating operations (e.g., Hall & Sundberg, 1987; Lamarre & Holland, 1985; Twyman, 1996). This may have contributed to inconsistent performances during tests. In the current study, the use of highly preferred stimuli contingent on correct responding on the maintenance trials may have increased the children's motivation to complete the tasks. Moreover, the temporal correlation between construction pieces and access to preferred items at the end of the session may have increased the value of the pieces as conditioned reinforcers. If this were the case, the observed transfer from mands to tacts may have been mediated by the motivating operation for the construction pieces that should have been in effect across both conditions.

Another variable that may have affected participants' performance was their extensive reinforcement history specific to the emission of mands and tacts. It is possible that a history of multiple-exemplar training of mands and tacts in more sophisticated speakers influences the degree of the transfer across operants (Horne & Lowe, 1996). Not surprisingly, the participant with more rudimentary verbal repertoire (Liam) showed inconsistent results during transfer tests. It is important to note that these children with autism had fairly extensive histories of one-to-one instruction (i.e., discrete-trial teaching) during the course of early intervention programming, whereas the typically developing preschool children in previous studies probably did not (e.g., Petursdottir et al., 2005). It is possible that the mere exposure to highly structured teaching with mands, tacts, and other relations may have played an important role in the results.

An important limitation of the present study is worth noting. A possible history with the

verbal stimulus used during testing sessions may have affected participants' performance. This same form of control was observed by Egan and Barnes-Holmes (2009). Initially for Juan, the instruction, ''What is this?,'' led to the response of tacting colors. When the instruction was changed to ''What is its name?'' the untrained verbal operant emerged. Similarly, Liam's absence of manding in the posttact training sessions could be attributed to the lack of control by the verbal stimulus ''What do you need?'' as opposed to ''What do you want?'' These results imply that, if Liam had been trained previously to respond to the question, ''What do you need?,'' he may have been able to mand the missing pieces. It would be beneficial for future studies to include some form of pretraining to guarantee instructional control (e.g., Miguel, Petursdottir, Carr, & Michael, 2008). In addition, future research also should provide detailed information on the history of verbal operant training and the current verbal repertoire so that we gain a better understanding of the repertoires that might lead to transfer.

Related to the point above, although the shapes of the construction tasks and their respective pieces were arbitrary, they were not monochromatic. It is possible that a previous reinforcement history with colors in the context of tact training somehow confounded the treatment and the results of this study. However, it is important to note that the two construction tasks had the same color schemes (i.e., red, green, yellow, and blue), and that the feature ''color'' never was correlated with reinforcement throughout the experiment. Nonetheless, it is recommended that future replications use monochromatic or clear construction pieces to decrease the likelihood that specific colors would come to control responding.

Results from this study add to our knowledge on how to teach verbal behavior to children with developmental delays. When teaching novel mands or tacts to children who have a certain level of speaker behavior, it may be possible to teach only one verbal operant, preferably the mand, while testing for the emergence of the other (i.e., tact). If the untrained operant does not emerge, then a multiple-exemplar instruction procedure may be adopted (Nuzzolo-Gomez & Greer, 2004).

Although previous studies have suggested that verbal operants are acquired independently in young children and children with disabilities, data from the current study suggest that, under certain conditions, training one verbal operant may lead to the emergence of the other. These conditions may include (a) the use of autoclitic frames during training, (b) preferred items as consequences, and (c) prior participant histories with mand and tact training. Future research should focus on identifying the variables that would dictate whether transfer is more or less likely to be seen, so clinicians can better design their language training protocols.

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